THE GEOLOGY OF THE WALES CANYON AREA WEST OF WALES, UTAH

A Thesis Presented in Partial Fulfillment
for the Degree of Bachelor of Science

by

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Approved by

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ILLUSTRATIONS

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

INTRODUCTION

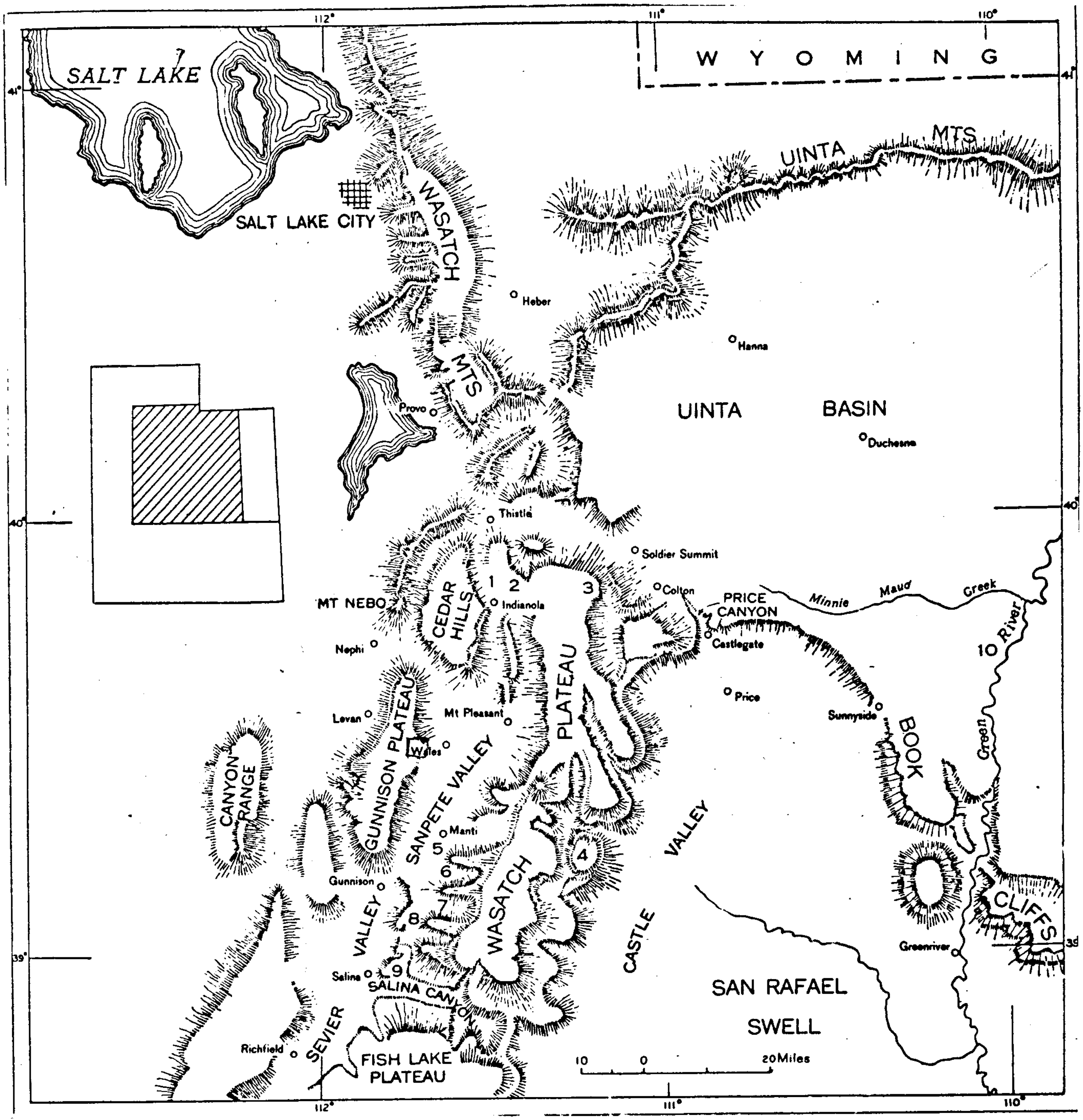
Location and Extent

The area this paper describes is located on the east side of the Gunnison Plateau in the Sanpete Valley of central Utah, approximately ninety miles South of Salt Lake City (see figure 1). The major portion of the area is located in sections 20, 23, 24, 27, 26, 25, T 15S, R2E. of Sanpete County. The Wales Canyon Area includes nearly nine square miles with a relief of over 1800 feet directly west of the town of Wales.

Present Work

The purpose of this paper is to present the geology of the Wales Gap Area in detail. The field work was done during the summer of 1967. It entailed the gathering of data for correlation of beds, establishing formation contacts, locating faults and unconformities. Sections of the Morrison formation, Indianola formation, Price River formation, North Horn formation, Flagstaff formation, and Colton formation were measured and described. The method used in measuring the sections varied. The tape measure was used where the beds were vertical and there was little topographic relief. The hand level was used where the beds were horizontal and the topography had considerable relief. The Brunton compass was used where the beds dipped opposite to the topographic slope. The field data was used to interpret the geologic

FIGURE 1



Index map of a portion of Utah, indicating the area described in this report.

Taken from E. M. Spieker, "Late Mesozoic and Early Cenozoic History of Central Utah", U.S. Geol. Surv. Prof. Paper 205D, 1946, p. 119.

history of the area, to make a stratigraphic column, and to make a geologic map with the aid of aerial photos.

Previous Work

Until about twenty years ago the geology of the Gunnison Plateau had been studied only in a brief and general manner.

C.E. Dutton (1880) in a report of the High Plateaus of Utah presents a general account of the geology of the region.

C.A. White (1886) described some fossils collected at Wales, Utah and near by localities.

G.B. Richardson (1906) wrote a paper on the coal near Wales. He pointed out that it was not valuable because it occurred in thin beds. He also remarked on its unusual occurrence in that it was deposited between two limestone beds. In 1907 Richardson published another paper dealing with the development of ground water in the Sanpete and Sevier Valleys. He mentioned the presence of a fault along the eastern base of the Gunnison Plateau. He also prepared a geologic map of the area.

F.R. Clark (1914) published a paper on the coal resources of the Gunnison Plateau near Wales.

E.M. Spieker (1946) published a comprehensive study of the Late Mesozoic and Early Cenozoic history of central Utah. In 1949 he published a Guidebook to the Geology of Utah for the area between the Colorado Plateaus and the Great Basin in central Utah.

In more recent years graduate students of the Ohio State University have contributed to the understanding of the geology westward of the Wasatch Plateau.

W.N. Gilliland (1948) did his doctors dissertation on the geology of the Gunnison Quadrangle.

D.A. Taylor (1948) did her masters thesis on the geology of the Gunnison Plateau front in the vicinity of Wales.

V.E. Katherman (1949) did his masters thesis on the Flagstaff limestone on the east front of the Gunnison Plateau of central Utah.

R.E. Hunt (1949) did his masters thesis on the Geology of the northern part of the Gunnison Plateau. Other works used for this paper are given in the bibliography.

Acknowledgments

The writer is indebted to the members of the staff of the 1967 Ohio State University summer field camp at Ephraim consisting of professors, M.P. Weiss, J.W. Collinson, C.H. Shultz, R.L. Threet and E.J. Szmuc for their assistance in the field. The writer is also indebted to his field partners, Cindy Coron and Ted Clark, for their helpful suggestions and for the use of their field notes to write this paper.

GEOGRAPHY

The Gunnison Plateau is the westernmost of the High Plateaus in central Utah. On the east it is bounded by the Sanpete Valley and on the west by the Sevier and Juab Valleys.

Near Wales the elevation of the plateau is about 7,500 feet. The plateau increases in elevation northward to a maximum of about 10,000 feet east of Nephi. Here it is separated from the Wasatch Mountains, by an east-west transverse valley occupied by Salt Creek. At the southern end of the plateau near the town of Gunnison the elevation decreases forming low foothills.

The western margin of the plateau is highly faulted and it is not as steep as the eastern front. The prominent feature of the eastern front is a coxcomb of upright conglomerate beds extending from Deer Canyon northward towards the town of Freedom. Both the eastern and western fronts of the plateau are cut by deep, narrow, steep sided canyons. The shape of these canyons appears to be controlled by the stratigraphy. They are narrow where cut into limestone and conglomerates and widen out where cut into shales.

Drainage

Much of the western portion of the Gunnison Plateau is drained by tributaries of the Sevier River into Sevier Lake. On the eastern front drainage is into the San Pitch River which flows south through the Sanpete Valley joining the

Plate 1

East front of the Gunnison Plateau, west of Wales, Utah.

Sevier River about three miles west of Gunnison. Most of the canyons have intermittent streams. The only perennial streams near Wales are found along the plateau front west of Wales reservoir, in Wales Canyon and in Peach Canyon. These are fed by springs in the North Horn formation. The water from these springs is used for irrigation in the Sanpete Valley.

Climate

The climate of central Utah is semi-arid. In the valleys the average annual rainfall is less than 14 inches. On the plateaus the rainfall is greater mainly due to their elevation and to a prevailing south-west wind. The wettest months of the year are July and August. Most of the precipitation during the summer occures in the form of afternoon thunder showers of short duration. Often during these thunder storms flood waters flow through the canyons, washing out roads and initiating slides. At the town of Moroni, which is about five miles north of Wales, the average annual maximum temperature is 61.9°F., the average annual minimum temperature is 31.7°F., and the average annual mean temperature is 46.8°F., as recorded by R.R. Woodley (1947). The temperature on the plateaus is much cooler. Frost often occures throughout the summer months resulting in isolated snow fields which do not melt until late in the summer.

Flora and Fauna

In the valleys vegetation is scant. Only hardy plants such as sagebrush, junipers, pinons, cacti and june grass persist in the semi-arid climate. North facing slopes of canyons and cuestas are often found overgrown with scrub oaks, while south facing slopes have very little vegetative cover. The plateau tops have abundant vegetation on them. Deciduous and evergreen trees flourish here. Many wild flowers grow in clearings and along trails. Grass provides pasturage for the cattle, horses and sheep which are kept on the plateaus during the summer months.

On the valleys the fauna consists mainly of snakes, lizards, and rabbits. The highlands provide an environment favorable for deer, porcupines, skunks, and wolfs. Hawks can often be seen gliding over the valleys.

Culture

The majority of the people are of the Mormon faith. In Manti they have built a beautiful temple from the nearby Green River limestone formation. In the past mining provided a livelihood for many people. Today, however, the economic needs of most families are met by agriculture or livestock raising. Since the growing season is short the most common crops grown are peas, wheat and alfalfa. The livestock raised include sheep, cattle and horses. In recent years turkey raising has become a large and profitable enterprise.

One railroad and several roads exist in the valley. A line of the Denver and Rio Grande Western Railroad crosses through Sanpete Valley and affords daily freight connections with Salt Lake City. U.S. Highway 89 provides a north-south means of travel. Near Wales a partially paved road runs parallel to the plateau front linking the small towns in the vacinity to one another. Numerous trails exist on the plateau tops. They are not recommended for use by cars, only for jeeps and trucks. The best of these trails extends from Wales over the plateau to Levan.

STRATIGRAPHY

General

The rocks of the Wales Canyon Area as summarized in Table 2, include sediments ranging from Late Jurassic to the present time. The rocks in this region are all sedimentary deposits of non-marine origin with the exception of the Twist Gulch formation which consists of marine silts and sandstones. The oldest rocks are found along the front of the Gunnison Plateau. They belong to the Twist Gulch formation. The thickness of the Twist Gulch near Wales is not known because eastward it becomes covered by alluvium. Westward the rocks get younger. Conformable with the Twist Gulch is the Morrison formation which consists of sandstones and conglomerates, it is also of Late Jurassic age. Unconformable with the Morrison are the Indianola sandstones and conglo-

FIGURE 2

FORMATIONS OF WALES CANYON

Era	System	Series	Formation	Lithology	Thickness
	Quaternary	Recent	Alluvium		
CENOZOIC	Tertiary	Eocene	Colton	Olive gray, shale and sandstone, yellowish pink limestone	150-700
		Paleocene	Flagstaff	Yellowish gray limestone	844
			North Horn	Yellowish brown sandstone, variegated shales	2500+
MESOZOIC	Cretaceous	Upper Cretaceous			
			Price River unconformity	Yellowish orange to gray is red sandstone and conglomerate	275-350
			Indianola unconformity	Light gray and greenish gray sandstones and conglomerates	0-700
	Jurassic	Upper Jurassic	Morrison	Red sandstones and conglomerates	0-150
			Twist Gulch	Red and white sandstone	300+

merates of Late Cretaceous age. Unconformable with the Indianola formation is the Price River conglomerate which forms the cocks comb and is of Late Cretaceous age also. Next, conformable with the Price River are the North Horn shales, coals, and sandstones. The North Horn strata are transitional Upper Cretaceous and Paleocene deposits. Two conformable Tertiary formations come next. They are the Flagstaff limestone, and the Colton shales and limestones. These two formations have low westward dips of about five degrees and form the top of the plateau.

Jurassic System

Twist Gulch Formation

Definition. The Twist Gulch formation was originally defined by E.M. Spieker (1946) as a member of the Arapien shale exposed on the north side of Salina Canyon lying between a compact red salt-bearing shale and the Morrison formation. At this location the Twist Gulch formation is believed to be 3,000 feet thick (Spieker, 1946, p. 125). C.T. Hardy and E.M. Spieker (1952) redesignated the unit as a formation because the strata could not be definitely correlated with Jurassic strata in either the San Rafael Swell or in southeastern Idaho.

Description and Distribution. At its type locality the Twist Gulch formation consists largely of red siltstone and reddish-gray sandstone, although about 175 feet of strata in the upper part of the formation in Salina Canyon consists of olive-green shale with thin sandstone and grit layers, light-gray sandstone and bluish-gray shale (C.T. Hardy, 1952, p. 22).

The Twist Gulch formation is exposed along the entire Gunnison front near Wales. The strata consist of red to chocolate brown sandstones and siltstones with a few thin beds of light gray sandstone. The sandstone grains are sub-rounded and range in size from medium to very coarse grained. Many of the beds exhibit cross-bedding and graded bedding, however, these features are not usefull for establishing tops and bottoms because they are equivical. In the Wales area the Twist Gulch formation does not contain fossils.

Stratigraphic Relations. Along the Gunnison front the Twist Gulch formation is conformable with the Morrison formation. Although, the contact is a fault plain in many places as indicated by slickensides. The beds are generally overturned, dipping east and they vary greatly in attitude. The dip averages about 50°. The strike averages about N 9° W but varies from N 36° E to N 25° W at 1.5 miles north of the Wales Canyon road. At another location about three-quarters of a mile north of the Wales Canyon road the beds change dip from 52° E, to vertical, to 70° W within only a few feet. These strikes and dips indicate that sevier folding has taken place within the formation.

Age and Correlation. C.T. Hardy (1952, p. 27) states that the Twist Gulch formation possibly corresponds to the Entrada, Curtis and Summerville formations of the San Rafael group. The Entrada formation has the similar red sandstone beds as the Twist Gulch formation. The 175 feet of olive green shale in the Twist Gulch formation corresponds lithologically and in stratigraphic position to the Curtis formation. The remainder of the Twist Gulch formation at Salina Canyon consisting of light gray sandstone, maroon shale and red siltstone is similar to the Summerville formation. The Twist Gulch formation is unfossiliferous as well as the Entrada and Summerville formations. The Twist Gulch formation is of Late Jurassic age and was deposited in a westward retreating Jurrassic sea (Baker, Dane, and Reeside, Jr., 1936, p. 54).

Morrison Formation

Definition. The Morrison formation was originally named by G.H. Eldridge, 1896, at Morrison, Colorado. It was redefined by Waldschmidt and LeRoy in 1944. The new type section is two miles north of Morrison in an exposure of 270 feet, along the north side of West Alameda Parkway roadcut. It consists of red, purple, brown, and greenish-white sandstone and red conglomerates.

Description and Distribution. E.M. Spieker (1946), designated 1,300 feet of sediments in the Salina district as Morrison (?). The unit consists of red pink, violet, gray and ochre shales; brown, gray and white sandstone; and conglomerate containing colored pebbles of chert and quartzite, whose maximum size is between two and four inches in diameter.

The Morrison (?) sediments occur at Salina and Thistle between the marine Jurassic and the marine sediments of Colorado age.

The exposure of the Morrison formation varies in thickness along the Gunnison front. Thrusting of the Twist Gulch westward over the Morrison was responsible for thining the exposed section in places. A 150 feet thick section of the Morrison was measured directly north of the Wales canyon road. The section consisted of two units, a lower sandstone unit 100 feet thick and an upper conglomerate unit 50 feet thick.

The sandstone exhibits a ridge to slope forming habit. It is composed of fine, moderatelly sorted, sub-angular to rounded grains of quartz with some feldspar grains. The color of the sandstone on a fresh surface is pale red to light pink. The weathered surface has large bleached areas. The weathered sandstone has a reddish brown color.

The conglomerate exhibits ridge forming habit. It consists of well rounded, moderately sorted quartzite and chirt pebbles and cobbles in a matrix of medium to coarse grains of quartz. Large float blocks of the conglomerate are often marked extensively with slicken sides parallel to the strike. No fossils were found in the Morrison formation.

<u>Stratigraphic Relations</u>. The Morrison formation is conformable with the older Twist Gulch formation along the Gunnison front. The Indianola Morrison contact on the other hand is an angular unconformity. The beds are generally overturned, dipping to the east. At Deer Canyon, 3000 feet

south of Wales Gap, the overturned Morrison beds are thrust over the Indianola and Price River conglomerates onto the North Horn formation. The strike averages about N 10^{o} W and the dip averages about 53^{o} E for the Morrison formation.

Age and Correlation. The sediments at Salina and Thistle are designated as Morrison (?) because they have not been traced to the Morrison of the San Rafael Group. However, the unit is similar lithologically, and it is so situated stratigraphically to be in favorable correlation with the San Rafael Morrison formation. Likewise the strata along the Gunnison front are designated as Morrison because of their stratigraphic position. Since the formation contains no fossils its age has not been definitely determined. The source of the sediments as suggested by Spieker (1946) was from the west or northwest.

Cretaceous System

Upper Cretaceous rocks are exposed in the Wasatch and Gunnison Plateaus, in the Cedar Hills and in the valleys adjacent to these highlands. Although the exposures are not continuous, conditions for determining stratigraphic relationships are favorable. The rocks are finer grained to the east and coarser grained to the west, suggesting that they were derived from high land masses to the west. These sediments are divided into two major groups by E.M. Spieker. The lower group includes the Mancos shale, the Star Point and the Blackhawk formations in the east, and the Indianola group west of San Pete Valley. The upper group consists of the Price River formation and part of the North Horn formation. These two groups are separated by an unconformity.

Indianola Formation

Definition. The Indianola formation was named by E.M. Spieker. It consists of a group of sandstones and conglomerates which are the oldest Upper Cretaceous units in central Utah (Spieker, 1946). The type locality is north of the town of Indianola, Utah. To the east the Indianola formation is subdivided into four formations, the Sanpete, Allen Valley, Funk Valley, and the Sixmile Canyon formations. However, on the Gunnison Plateau the Indianola formation is undifferentiated.

Description and Distribution. West of the Wasatch Plateau the Indianola formation consists of great thicknesses, 8,000 to nearly 15,000 feet of conglomerate and sandstone with locally interbedded red and variegated shale, freshwater limestone, and littoral marine sandstone (Spieker, 1949, p. 21). The best exposures of the formation are in the Cedar Hills, and in the canyon of Chicken Creek east of Levan.

The thickness of the Indianola outcrop varies from 0 to 700 feet along the front of the Gunnison Plateau near Wales. The maximum thickness was measured along the front, 1.2 miles north of the Wales Canyon road. The thickness of the exposure here is attributed to an east west fault which is upthrown on the southern side. This thickening of the Indianola formation on the upthrown side indicates that it thickens at depth. At Deer Canyon, 3,000 feet south of the Wales Canyon road the Indianola disappears under sediments of the Morrison formation which have been thrust over it.

Along the Gunnison front the Indianola generally consists of a basal sandstone member and a higher conglomerate member which often contains sandstone lenses. The sandstone member exhibits a ridge forming habit. It has a massive to friable texture. It consists of fine, moderately sorted, sub-rounded to well-rounded quartz grains. On a fresh surface it is yellowish gray, weathering to dusky yellow on the exposures. The conglomerate member is also ridge forming. It consists of well-rounded, poorly sorted quartzite 60%, limestone 20%, and sandstone 20% pebbles and cobbles in a matrix of well rounded quartz grains. The cement is both siliceous and calcitic. The color varies from light gray to dark gray. No fossils were found in the Indianola formation.

Stratigraphic Relations. The Indianola formation appears to be deposited unconformably on the Morrison formation. The Indianola-Price River contact is also an angular unconformity. The depositional contact of the Price River and Indianola contact is clearly seen on the south side of Wales Gap and in several places north of Wales Gap along the Gunnison front. The Indianola formation is generally overturned, at Wales Gap it has a strike of N 9° W and a dip of 73° E. Much of the Indianola outcrop is highly jointed and distorted. Often it is difficult to get an accurate attitude for the beds.

Age and Correlation. The age of the Indianola is Upper Cretaceous. It is probably equivalent to the Mancos shale in the eastern Wasatch Plateau. E.M. Spieker (1946) states that the source of the Indianola sediments was from folded mountains not far west of the southern Wasatch Mountains. The thickening of the formations on the western side of the Gunnison Plateau seems to support the concept of a near by western source of the sediments.

Price River Formation

Definition. The Price River formation was defined by Spieker and Reeside (1925, p. 445), at Price Canyon, northwest of Castlegate, Utah. It included the strata between the Blackhawk formation and the North Horn formations. At its type locality the Price River formation consists of two members: the basal cliff forming Castlegate member, composed of massive, white to brown, medium to coarse grained sandstone; and an upper, less massive slope-forming member of similar lithology. In Price Canyon the formation is about 1,100 feet thick.

Description and Distribution. The Price River formation consists largely of conglomerate which contains pebbles and cobbles of quartzite and limestone. Boulders of quartzite are also found as is the conglomerate at Thistle. The color of the conglomerate varies from red to dull gray to brown.

Interbedded with the conglomerate are medium to coarse grained sandstone lenses. In general the formation is coarse towards the west and finer towards the east.

The Price River formation crops out throughout the Wasatch Plateau and in adjoining regions to the west and east. Its most notable extension outside of central Utah is in the Book Cliffs, where the Castlegate sandstone member is recognized as far east as the Utah--Colorado boundary (Spieker, 1949, p. 130).

Along the Gunnison front west of Wales, the Price River formation crops out as a prominent cocks comb. Its areal thickness varies from 0 to 350 feet. In general the thickest outcrop is in the northern part of the front. It thins rapidly south of Wales Gap until it is only a few feet thick at Deer Canyon, where it disappears under the overthrust Morrison beds. The thining of the Price River and its disappearance indicate the possibility of a positive area having existed between Deer Canyon and the Gunnison front two miles south of Peach Canyon where the formation again crops out. This positive area prevented the conglomerates from being deposited there.

A section of the Price River conglomerate was measured at Wales Gap along the north side of the road. Here the Price River formation can be divided into three units: a lower conglomerate unit, 135 feet thick; a sandstone unit, 90 feet thick; and an upper conglomerate unit, 100 feet thick.

The basal conglomerate looks very much like the Indianola conglomerate and may in fact be reworked Indianola because an angular unconformity separates the two conglomerates. This basal conglomerate is a light gray color. Its weathered surface is darker. The texture of the poorly sorted matrix is sub-angular to rounded. The grain size ranges from medium to very coarse. The conglomerate is composed of pebbles of quartzite and sandstone cemented with silica. The bedding is not well defined.

Next comes the sandstone unit which is pinkish gray in color on the fresh surface and grayish orange in color on the weathered surfaces. The sub-rounded texture is made up of medium to coarse grains of quartz 95% and feldspar 5%. The outcrop forms cliffs and ridges. This unit also lacks distinct bedding.

The upper conglomerate unit is brown to dark red in color. It is made up of well rounded quartzite pebbles and cobbles of a wide range of colors from light gray to dark red in a matrix of rounded sand. Bedding is evident only after weathering of the matrix and where sandstone lenses are in contact with the conglomerate. This unit is the predominant cocks comb former. No fossils were found in the Price River formation.

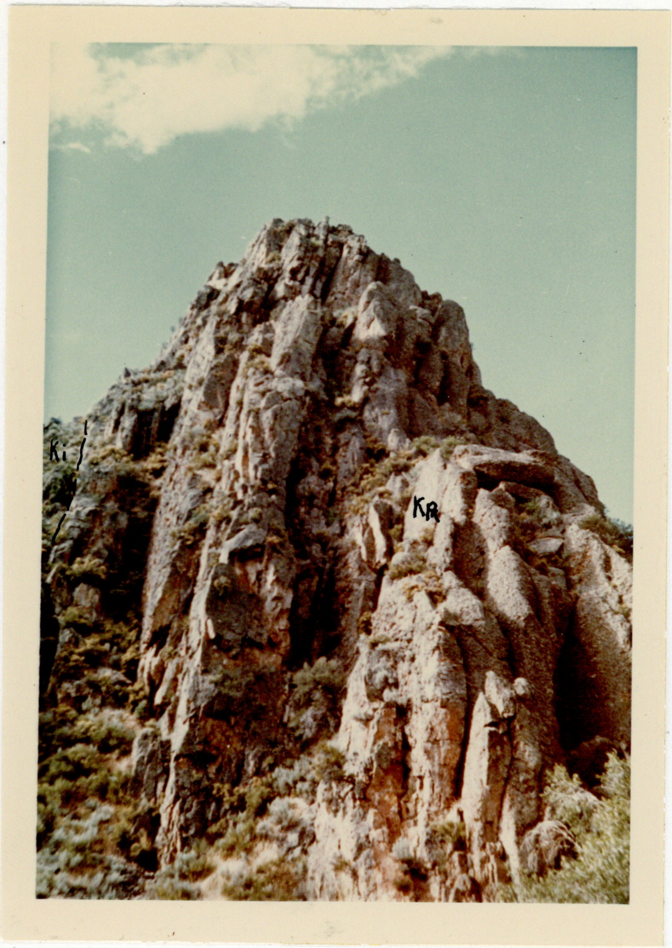
<u>Stratigraphic Relations</u>. Along the Gunnison front the Price River--Indianola Conglomerate contact is an angular unconformity. The angular relationship can clearly be seen at Wales Gap and at Deer Canyon. The North Horn Price River contact, on the other hand, is transitional. On the south side of Wales Gap the Price River formation is vertical further

Plate 2

A. Vertical Price River conglomerate on the south side of Wales Gap with part of Indianola conglomerate contact shown to the left.

B. Exposure of the gray Indianola conglomerate to the left and red Morrison sandstone to the right, on the north side of Wales Canyon road just east of the cockscomb.

Plate 2



A

B

south at Deer Canyon it is overturned and dipping 80° E. before it disappears under the Morrison formation. North of Wales Gap the Price River displays both eastward and westward dips. The strike also varies from N 20° W to N 16° E.

Age and Correlation. The Price River conglomerates of the Wasatch Plateau have yielded some fossils which J.B. Reeside, Jr. has identified to be characteristic of the Upper Cretaceous.

The Castlegate member of the Price River formation is approximately equivalent to the Fruitland and the Kirtland formations of the San Jaun region; the Adaville formation of western Wyoming; the Bearpaw shale and Lennys sandstone of Montana. The thick coarse conglomerate was derived from the erosion of Pennsylvanian, Cambrian and probably pre-Cambrian sediments of the Wasatch Range which were folded and uplifted by the early Laramide orogeny (E.M. Spieker, 1949, p. 24). The conglomerates were probably deposited near the break in slope of the newly formed mountains.

Cretaceous and Tertiary Systems

North Horn Formation

Definition. The North Horn formation was originally classified as the lower member of the Wasatch formation which included the Colton, Flagstaff, North Horn and Price River formations. E.M. Spieker (1946, p. 132) officially renamed the lower member of the Wasatch formation the North Horn formation. Its type locality is North Horn Mountain east of the Wasatch Plateau. Here it has a total thickness of 1650 feet. It consists of variegated shale, sandstone, conglomerate, and fresh-water limestone. This lithology is considered to be characteristic of an alternating fluvatile and locustrine depositional area.

Description and Distribution. Away from its type locality the four fold division of the North Horn formation gradually diminishes. Instead it becomes more unified having fewer subdivisions. However, laterally the North Horn formation exhibits many facies changes. For example, along the Gunnison Plateau, the lower part of the formation at Wales Gap is predominently shale. But, from Peach Canyon southward a facies change occures where by the lower part of the North Horn formation is predominently composed of sandstone beds forming a steep front along the plateau especially at Point of the Mountain.

On the Wasatch Plateau the formation thickens to the north and east. It attains a thickness of 2,200 to 2,500 feet between Castlegate and Soldier Summit. Westward it generally thins with a minimum of about 500 feet having been observed on Salina Creek (Spieker, 1946, p. 133). The formation can be traced as far east as the Book Cliffs. The lower parts of the formation contain thin beds of coal situated stratigraphically between beds of limestone.

Near Wales Canyon the lower part of the formation is an aggregate of variegated shale, conglomerate, sandstone, some limestone and a few thin beds of coal. Alternating beds of shale, limestone and sandstone are predominent in the upper parts of the formation. The description of the lithologic types is equally applicable to both the upper and lower parts of the formation. Shale is the most apparent type of lithology. It varies in color from light yellow, yellowish brown, light gray, to maroon. The shale is calcareous and it is the slope forming lithology of the formation. The conglomerate is a thin unit, usually not more than 10 feet in thickness. It consists of well-rounded, poorly sorted quartzite and some carbonate pebbles in a matrix of medium, subangular to rounded grains of quartz. The color is greenish gray to pale orange yellow. It has a ridge forming habit. The sandstone is buff, tan, gray and reddish brown in color. It varies from fine to coarse grained and has a calcareous cement sometimes. It caps the cuestas in the area. The limestone is light gray to dark gray, buff or tan in color, and it is commonly fossiliferous. Coal is present on the south side of Wales Canyon road about 2,500 feet west of Wales Gap. It occures between limestone beds. In the Wales Canyon area the North Horn formation is the thickest formation. It has a thickness of over 2,000 feet. It is present in the entire area. Near its base it exhibits a facies change. The facies change is evident at the small canyon just south of Deer Canyon. At this small canyon the facies is a reddish brown argillaceous sandstone, weathering in a badland fashion. From Deer Canyon northward the facies consists of variegated shales being disected deeply by gullies.

The following is a section of the North Horn coal seams, measured from the stream bed on the south side of Wales Canyon road about 2,500 feet west of Wales Gap.

		Thickness Feet	Inches
16.	Limestone, light gray................	13	4
15.	Shale, gray..........................	1	6
14.	Limestone, gray......................	3	1
13.	Coal.................................		5
12.	Limestone, light gray, lithographic..	1	3
11.	Coal.................................	4	10
10.	Limestone, light gray................		9
9.	Coal.................................	2	2
8,	Limestone, dark gray, fossiliferous, shell fragments.....................	2	4
7.	Limestone, light gray................	4	6
6.	Coal.................................		5
5.	Limestone, light gray, lithographic..	1	9
4.	Coal.................................		5
3.	Limestone, light gray................	5	2
2.	Shale, gray..........................	1	9
1.	Limestone, light gray................		9
	Total................................	44	5

North Horn Shales, stream bed.

The following is a section measured north of the Wales Canyon road from the top of the Price River formation west to the basal Flagstaff limestones.

		Thickness Feet	Inches
130.	Shale, red..........................	22	
129.	Limestone, yellowish brown, lithographic..............................	3	
128.	Shale, like unit 122................	11	
127.	Sandstone like unit 125.............	2	
126.	Shale, like unit 124................	22	
125.	Sandstone, yellowish brown, quartz and chirt grains are medium and angular.............................	3	
124.	Shale, yellowish brown, arenoceous..............................	22	
123.	Limestone, yellowish brown, arenoceous, weathers pale yellow.........	4	
122.	Shale, pale yellow..................	17	
121.	Sandstone, like unit 117............	4	
120.	Shale, like unit 109................	11	
119.	Limestone, brown, fine texture, weathers pale yellow................	2	
118.	Shale, like unit 109................	23	
117.	Sandstone, pale yellow, medium angular quartz grains...............	2	
116.	Shale, like unit 109................	22	
115.	Sandstone, pale yellow, angular coarse quartz grains, some pink and milky quartz, chirt also present	5	
114.	Limestone, yellow brown, fossiliferous, fine texture................	1	
113.	Shale, like unit 109................	16	
112.	Limestone, brown, fractured, weathers pale yellow................	2	
111.	Shale, like unit 109................	34	

		Feet	Inches
110.	Sandstone, pale yellow on fresh surface, yellowish brown on weathered surface, coarse angular grains.............................	3	
109.	Shale, pale yellow..................	5	4
108.	Limestone, like unit 106............	2	
107.	Shale, maroon.......................	11	
106.	Limestone, yellow brown, lithographic, weathers pale yellow.......	3	
105.	Shale, like unit 99.................	5	4
104.	Limestone, gray, fine texture, weathers light gray.................	2	
103.	Shale, like unit 99.................	38	
102.	Limestone, like unit 96.............	12	
101.	Shale, like unit 99.................	3	
100.	Limestone, pale yellow, vertically jointed............................	1	
99.	Shale, pale yellow..................	21	
98.	Limestone, like unit 96.............	5	
97.	Shale, like unit 87.................	12	
96.	Limestone, pale yellow, vertically jointed, lithographic...............	12	
95.	Shale, like unit 87.................	16	
94.	Limestone, yellowish brown, arenoceous..............................	11	
93.	Shale, like unit 87.................	10	8
92.	Claystone, pale yellow, calcareous..	2	
91.	Shale, like unit 87.................	16	
90.	Sandstone, pale yellow on fresh surface, yellow brown on weathered surface, medium coarse angular grains of quartz.....................	6	

		Feet	Inches
89.	Shale, like unit 87..................	16	
88.	Limestone, pale yellow, fine massive texture......................	1	6
87.	Shale, pale yellow..................	16	
86.	Sandstone, light brown, coarse angular grains, white and pink quartz present, chirt present...............	3	
85.	Shale, like unit 79..................	16	
84.	Limestone, like unit 82..............	2	
83.	Shale, like unit 79..................	11	
82.	Limestone, pale yellow, pitted surface, fine texture..................	3	
81.	Shale, like unit 79..................	11	
80.	Limestone, pale yellow...............	2	
79.	Shale, yellowish brown...............	16	
78.	Limestone, brown, chirty, weathers pale yellow..........................	5	4
77.	Shale, like unit 75..................	5	4
76.	Limestone, brown, arenoceous, weathers pale yellow....................	12	
75.	Shale, yellowish brown...............	21	4
74.	Claystone, gray brown, fine rounded quartz grains are present, weathers pale yellow..........................	1	6
73.	Sandstone, yellowish brown, subrounded, medium grained, quartz and feldspar.........................	2	6
72.	Shale, pale yellow...................	27	
71.	Limestone, brown, argillaceous, weathers pale yellow.................	6	
70.	Shale, like unit 62..................	26	4
69.	Limestone, pale yellow, lithographic.	3	

		Feet	Inches
68.	Shale, like unit 62..................	12	
67.	Limestone, pale yellow, argillo-ceous................................	46	
66.	Shale, like unit 62..................	24	
65.	Limestone, light gray, lithographic, weathers yellowish brown.............	2	
64.	Shale, like unit 62..................	10	
63.	Limestone, like unit 61..............	1	
62.	Shale, light gray....................	8	
61.	Limestone, gray, fine texture, wea-thers yellowish gray.................	1	
60.	Shale, like unit 52..................	6	
59.	Limestone, gray, fossiliferous, gastropod Helix......................	3	
58.	Shale, like unit 52..................	26	6
57.	Limestone, brown, argillaceous.......	2	
56.	Shale, like unit 52..................	16	
55.	Limestone, yellow, lithographic......	4	
54.	Shale, like unit 52..................	4	
53.	Limestone, like unit 51..............	1	
52.	Shale, gray..........................	48	
51.	Limestone, gray, fossiliferous, gas-tropod Helix, weathers yellow gray...	1	
50.	Shale, maroon, weathers into small fragments...........................	55	
49.	Limestone, gray......................	1	
48.	Shale, like unit 36..................	43	
47.	Sandstone, yellowish brown, sub-rounded coarse quartz grains, jointed.............................	10	

		Feet	Inches
46.	Shale, yellowish brown...............	32	
45.	Shale, like unit 36..................	91	
44.	Shale, maroon........................	12	
43.	Sandstone, yellowish brown, argill-aceous, sub-rounded quartz and feld-spar grains, coarse grained, massive.	11	
42.	Shale, pale yellow, arenaceous.......	6	
41.	Sandstone, yellowish brown, fine grained, sub-rounded..................	3	
40.	Shale, like unit 36..................	16	
39.	Sandstone, yellowish brown, basal 3 feet conglomeratic quartz and feld-spar grains are sub-rounded, massive, calcareous cement.....................	11	
38.	Shale, like unit 36..................	64	
37.	Limestone, yellowish brown, arena-ceous, weathers into flaky plates....	12	6
36.	Shale, yellow........................	7	6
35.	Shale, pale yellow, calcareous.......	160	
34.	Limestone, pale yellow, argillaceous, bedding 1-3 feet thick, weathers yellow brown.........................	32	
33.	Limestone, yellow gray, fossiliferous gastropod Helix, bedding 3-18 inches thick, thin coal beds containing plant spores, ridge forming..........	48	
32.	Shale, gray, arenaceous..............	10	
31.	Limestone, gray brown................	2	5
30.	Shale, gray brown....................	16	
29.	Limestone, yellow, argillaceous......	5	
28.	Limestone, like unit 24..............	2	
27.	Shale, yellow gray...................	6	4

		Feet	Inches
26.	Limestone, like unit 22..............	2	
25.	Shale, brown gray, calcareous........	16	
24.	Limestone, yellow brown..............	2	6
23.	Shale, brown gray, argillaceous......	21	
22.	Limestone, gray, fossiliferous, gastropod Helix......................	1	8
21.	Shale, like unit 11..................	18	
20.	Limestone, like unit 18..............	1	6
19.	Shale, like unit 11..................	42	
18.	Limestone, gray, fossiliferous, gastropod Helix......................	1	
17.	Shale, like unit 11..................	12	
16.	Limestone, light gray, argillaceous..	1	
15.	Shale, like unit 11..................	112	
14.	Shale, gray brown, calcareous........	16	
13.	Shale, like unit 11..................	37	
12.	Sandstone, light yellow brown, medium grained, some cross bedding...	8	
11.	Shale, light yellow gray, calcareous.	37	
10.	Shale, red, calcareous...............	26	
9.	Shale, like unit 7...................	69	
8.	Sandstone, brownish yellow, fine grained, massive, calcareous.........	5	
7.	Shale, light yellow, calcareous......	53	
6.	Sandstone, light brown, fine grained, massive..............................	10	
5.	Sandy conglomerate, light gray to orange yellow, poorly sorted quartz and carbonate pebbles................	49	
4.	Shale, weathered gray................	56	

Plate 3

View west thru Wales Gap

		Feet	Inches
3.	Sandstone, grayish orange, well rounded quartz grains................	11	
2.	Shale, maroon to gray................	60	
1.	Conglomerate, light gray, pebbles quartzite, sub-angular to rounded, average 2.5 inches in diameter.......	11	
	Total..............................	2291	

Price River Formation

Stratigraphic Relations. In a large part of the area the North Horn formation lies conformably on the Price River formation. The contact is gradational and difficult to trace. At Wales Gap a conglomerate bed was chosen as the base of the North Horn because it had smaller pebbles in it than Price River Conglomerate. Where the Price River formation is not present, the North Horn formation lies at an angular unconformity with the Indianola and Morrison formations. The dip of the North Horn formation is greatest at its base where it is vertical in some places. Westward from the cocks comb, the dip decreases rapidly at first and then gradually until the strata has a dip of only about 5° W at the top of the formation. The strike varies along the base from about N 20° W to N. 16° E. However, westward the strike becomes a uniform N 10° W. The contact between the North Horn formation and the overlying Flagstaff limestone is both conformable and gradational. The contact was arbitrarily placed above the dominantly red clastics and below the predominant ridge forming limestone.

Age and Correlation. The age of the North Horn formation at the type locality has been determined to be transitory between late Cretaceous and early Paleocene (Spieker, 1946, p. 135). This conclusion is based on the discovery of Cretaceous reptilian remains in the lower 500 feet of the formation and the discovery of Paleocene mammalion remains in the upper part of the formation. The North Horn formation is approximately equivalent to the Lance and lower Fort Union formations of Montana, Wyoming and the Dakotas. Also, to the south it is equivalent with the Ojo, Alamo, Puerco and Torrejon of the San Jaun Basin (Spieker, 1946, p. 135).

The North Horn formation is principally a flood plain deposit. Gravels were deposited in channels and alluvial fans. Sand and mud were deposited on the more level parts of the flood plain. Coal and limestone were deposited in temporary lakes found on the flood plain. Sediments were derived from an orogenic belt to the west.

Tertiary System

Flagstaff Formation

Definition. The Flagstaff limestone was originally defined as the middle member of the Wasatch formation (Spieker and Reeside, 1925, p. 448). Because of its thickness and extent over central Utah, it is one of the major stratigraphic markers in the region. In view of this, Spieker (1946, p. 135) elevated the Flagstaff limestone to formational rank. Its type locality is Flagstaff Peak in the southern part of the Wasatch Plateau.

Description and Distribution. The Flagstaff formation extends throughout the Wasatch Plateau. Here it ranges in thickness from 200 feet to 1,500 feet and is generally thicker westward and southwestward. The Flagstaff formation is dominantly freshwater limestone. In certain areas it is not only associated with shale and sandstone, but also gypsum, volcanic ash, oil shale and other bituminous and carbonaceous beds. The three most common types of limestone found composing the Flagstaff formation are: dark gray, containing fossils; dark gray, massive, relatively unfossiliferous, and cream to light tan limestone (Spieker, 1949, p. 31). The Flagstaff formation is known to extend to the plateaus north of the Book Cliffs. Gilliland (1951, p. 25) traced the formation as far west as the Pavont Plateau as well as to the Valley Mountains. Southward the extent of the Flagstaff formation is not yet fully known, but there is reason to think that it continues into the southern High Plateaus (Spieker, 1949, p. 32).

The Flagstaff formation is present in the Wales Canyon area. It forms a prominent white cliff above the North Horn formation. In the Wales Canyon area the lithology of the Flagstaff is predominently limestone, but it also consists of some beds of shale, sandstone, and mudstone. The sandstone is generally gray to brown in color. It is medium to fine grained and usually held together by calcareous cement.

The shale is generally light gray to brown in color. It is commonly fissile, arenaceous, and contains appreciable amounts of calcite. The shales are slope forming. The mudstones are yellowish gray to pale green in color. They are arenaceous and calcareous exhibiting a slope forming habit. The limestone displays a cliff forming habit. It is usually massive, but it also can be slabby or platy. The limestone ranges in color from gray to pale yellow. It is often fossiliferous. Fossils collected included the fresh water gastropods Viviporus, Bulimulus and Hydrobia.

The following is a section of the Flagstaff formation measured on the west side of a tributary valley about one mile west of Wales Gap. The section was measured from the top of the maroon North Horn shales.

Flagstaff Limestone etc. under cover:

		Feet	Inches
33.	Limestone, gray, hard, weathers light gray, arenaceous...............	18	0
32.	Shale, light gray, calcareous........	6	1
31.	Limestone, gray, argillaceous, jointed...............................	17	6
30.	Limestone, light gray, soft, shale lenses................................	8	5
29.	Shale, yellowish brown, fissile......	11	7
28.	Limestone, gray, argillaceous, weathers with pitted surface.........	5	5
27.	Shale, gray, calcareous.............	7	0
26.	Limestone, light gray................	9	4
25.	Limestone, pale yellow, arenaceous...	1	0

		Feet	Inches
24.	Limestone, light brown, argillaceous, weathers to pale yellow..............	75	0
23.	Shale, grayish brown, soft, calcareous, arenaceous.................	11	6
22.	Limestone, gray, argillaceous........	5	5
21.	Limestone, yellowish brown, resistant..........................	5	0
20.	Limestone, pale yellow, argillaceous, weathers to form slope..............	14	0
19.	Shale, brown, weathers yellowish brown.............................	2	6
18.	Limestone, light gray, crystaline mottled, resistant..................	5	6
17.	Shale, gray, calcareous, arenaceous..	3	8
16.	Shale, light gray, calcareous........	4	8
15.	Limestone, brownish yellow, crystaline, weathers pale yellow........	10	5
14.	Limestone, light gray, hard, weathers to chips......................	7	10
13.	Limestone, grayish brown, weathers light gray..........................	3	0
12.	Limestone, tan, cherty, hard.........	15	8
11.	Shale, maroon, arenaceous, mottled...	5	3
10.	Limestone, light brown, argillaceous.	10	6
9.	Sandstone, yellow brown, fine to medium grained, calcareous...........	5	7
8.	Sandstone, argillaceous, grayish brown, soft, weathers light gray.....	20	0
7.	Sandstone, pale yellow, calcareous, hard................................	10	0
6.	Limestone, gray, argillaceous, weathers pale yellow..................	4	6

		Feet	Inches
5.	Limestone, gray, arenaceous..........	6	0
4.	Sandstone, gray, argillaceous, fine grained............................	6	6
3.	Sandstone, reddish brown, chirty, calcareous...........................	8	0
2.	Shale, gray brown, arenaceous, calcareous...........................	13	0
1.	Limestone, tan, arenaceous, weathers yellow brown..................	6	0
	Total..............................	353	10

North Horn formation
Shale, weathers deep red, slope forming

Stratigraphic Relations. The Flagstaff formation is conformably underlain everywhere in the Wales Canyon area by the North Horn formation. The contact with the underlying North Horn formation is gradational and has been placed arbitrarily where the limestone becomes more continuous. However, in some localities a transitional relationship does not exist between the two formations. At the southeastern tip of the Gunnison Plateau near Christianburg the Flagstaff overlies the North Horn in an angular unconformity. Also at Salina Canyon and at many places in the western part of the Gunnison Plateau the Flagstaff overlies the older folded complex in angular unconformity (Spieker, 1949, p. 33). The upper contact of the Flagstaff formation is more consistent. It grades into the overlying Colton or Green River formation where the Colton is absent. In the Wales Canyon area the Flagstaff intertongues with the Colton formation.

In general the contact between the two formations is rather sharp. The sharp contrast is due to the yellow-brown, fine-grained basal sandstone of the Colton formation. The Colton is less resistant than the Flagstaff formation, thus a sharp break results in the topography. The Flagstaff formation dips gently to the west about 4° and it has a strike of N 10° W.

Age and Correlation. Spieker (1946, p. 136) has reported the age of the Flagstaff as being Paleocene on the basis of certain freshwater mollusks and its stratigraphic relation to the underlying medial Paleocene North Horn formation. The Flagstaff formation is correlated with the Fawkes formation of southwestern Wyoming and with the uppermost Fort Union strata of the northern Great Plains. The known extension of the Flagstaff into the Pavant Plateau suggests a possible correlation with the Bryce Canyon formation of southern Utah (Gilliland, 1951, p. 32).

The Flagstaff formation represents deposits from a fresh water lake which may have been formed from obstruction of drainage due to the Pre-Flagstaff orogeny or from geosynclinal downwarping (Spieker, 1946, p. 160). Fossils identified in the Flagstaff formation were fresh water gastropods Viviparus and Lioplacodes.

Colton Formation

Definition. The Colton formation was defined by Spieker (1946, p. 139) as equivalent to the original upper member of the Wasatch formation. It was named for exposures in hills north of Colton at the head of Price Canyon, Utah County. At its type locality the Colton formation is 1,500 feet thick, it underlies the Green River formation, overlies the Flagstaff formation and both contacts are clearly defined.

Description and Distribution. Typically the Colton formation consists of gray, green, and red variegated shales; coarse-grained green-buff sandstone; light-gray medium-grained or brown sandstone; and some dark to light-gray dense limestone. The known distribution of the Colton formation is restricted to the northern and western margins of the Wasatch Plateau, the Gunnison Plateau, and the southeastern margin of the Valley Mountains (Spieker, 1949, p. 34). It is also widely exposed in the Tavaputs Plateau.

In the Wales Canyon area the Colton formation is present on top of the central part of the plateau. Here it is intertongued with the Flagstaff formation. A larger exposure of the Colton exists at the extreme south-west corner of the area. Here the lithology of Colton consists of limestone, shale, and mudstone. The limestone is arenaceous, slabby, yellowish gray to pinkish gray in color. It has a slope forming habit. The sandstone is fine grained, moderately sorted, calcareous and micaceous. It is light olive gray to yellowish gray in color, and weathers to pale green. It displays a ledge forming habit. The mudstone is loosely cemented, contains plant and lithic fragments. It is light greenish gray in color and has a slope forming habit. The following section of the Colton formation was measured on the top of the plateau in the southwest corner of the area.

		Feet	Inches
26.	Sandstone, greenish gray, micaceous, fine grained, calcareous............	4	0
25.	Limestone, greenish gray, argillaceous, blocky..........................	15	7
24.	Sandstone, greenish gray, calcareous, micaceous, mottled, fine grained.....	72	9
23.	Sandstone, yellowish gray, fine-grained, calcareous, weathers pinkish gray................................	28	5
22.	Sandstone, light olive gray, fine grained, argillaceous, calcareous....	8	1
21.	Mudstone, greenish gray, calcareous, blocky................................	22	5
20.	Sandstone, yellowish gray, fine-grained, micaceous...................	56	2
19.	Limestone, pale yellowish brown, hard, weathers yellow.................	1	0
18.	Shale, greenish gray, calcareous, mottled, weathers brownish gray......	10	5
17.	Sandstone, yellowish gray, fine-grained, calcareous, friable, massive..............................	15	7
16.	Mudstone, greenish gray, arenaceous, calcareous..........................	10	5
15.	Sandstone, yellowish gray, fine grained, calcareous, massive, weathers reddish gray..................	30	0
14.	Mudstone, brownish gray, loosely cemented, contains plant and lithic fragments...........................	130	0
13.	Limestone, pinkish gray, hard, massive..............................	4	0
12.	Limestone, pinkish gray, slabby......	31	2
11.	Sandstone, yellowish gray, fine-grained, weathers greenish gray......	5	2

		Feet	Inches
10.	Limestone, yellowish gray, slabby weathers pinkish gray................	25	0
9.	Sandstone, pale olive, fine grained, friable, weathers yellowish gray.....	1	0
8.	Limestone, pinkish gray, slabby......	44	8
7.	Sandstone, yellowish gray, fine-grained................................	0	6
6.	Limestone, pinkish gray..............	15	6
5.	Sandstone, light olive gray, fine-grained, calcareous..................	2	0
4.	Limestone, yellowish gray, slabby....	5	2
3.	Sandstone, light olive gray, fine-grained, calcareous, micaceous, weathers pale green..................	1	0
2.	Limestone, yellowish gray, arenaceous, slabby.......................	5	2
1.	Sandstone, light olive gray, fine grained, micaceous, calcareous.......	0	6
	Total.................................	547	10

Flagstaff formation

Stratigraphic Relations. In the Wales Canyon area the Colton formation is conformable on the Flagstaff formation. In some places it also intertongues with the Flagstaff formation. However, the contact is distinct since the basal Colton consists of a nonresistant sandstone which is responsible for a break in slope between the two formations. The dip of the Colton formation averages about 3° W and the strike is N 10° W.

Age and Correlations. Spieker (1949, p. 34) states that the age of the Colton is probably early Eocene. The age is not sure because no diagnostic vertebrate fossils have been found and invertebrate fossils need further study. The Colton formation has been correlated with the Knight formation in southwest Wyoming and with the Sand Coulu and Gray Bull of the Big Horn Basin, Wyoming (Gilliland, 1951, p. 37).

The sequence of Colton sediments and the intertongueing with the Flagstaff formation indicate that the Colton sediments were deposited under alternating fluviatile and lacustrine conditions. The sandstones are dominantly fluviatile in origin, while the shales and limestones were probably deposited under shallow lacustrine conditions.

Recent Deposits

In several places along the Gunnison front, old pediment remnants are visible. In the Wales Gap area there are two distinct pediment surfaces, an old one and a younger one below it. The older pediment surface which consists largely of weathered Indianola, Morrison and Price River formations is mined in many areas for gravel. A gravel pit is located about 1,000 feet east of Wales Gap on the north side of the road. The upper pediment consists largely of blocks of North Horn sandstone and Flagstaff limestone. The youngest sediments of course are being deposited in San Pete Valley as alluvium. The thickness of the alluvium is not known. But judging from the amount of erosion of the plateau the depth of the alluvium must be considerable.

STRUCTURAL GEOLOGY

Regional Structure

The Gunnison Plateau is in the area of structural transition between the Colorado Plateaus and the Great Basin. To the north are the southern Wasatch Mountains whose structure consists of an eroded overturned anticline which has been thrust eastward. To the northeast of the Gunnison Plateau are the Cedar Hills. The structure of the west central part of the Cedar Hills is anticlinal. Here as well as to the north the sediments have been folded. The southern part of the Cedar Hills has been disrupted by normal faulting. Bordering the Gunnison Plateau on the east is Sanpete Valley. Its structure must be inferred from known trends on its margins because it is covered with alluvium. Spieker (1949) states that the Sanpete Valley is underlain by a folded complex produced in the early Laramide and later compressional movements. On the eastern flank of the Sanpete Valley is the Wasatch Plateau. It consists of flat lying mesozoic and cenozoic sediments. Its eastern side is an escarpment and its western side is a monoclinal flexure that has several N-S antithetic faults. To the southeast of the Gunnison Plateau are the Valley Mountains. Here the strata trend slightly east of north forming an eastward dipping monocline.

Local Structure

Structurally the Gunnison Plateau is a broad asymetric syncline with a steep overturned eastern limb. This structure plunges southward from near the northern end of the plateau and extends beneath the alluvium of the Sevier Valley in the vicinity of Gunnison, Utah. The east front of the Gunnison Plateau has a marginal thrust fault along its length. The west front is characterized by normal faults, monoclinal structure in the southern half and by a belt of intensely folded Arapien shale in the northern half (Spieker, 1949, p.41).

Folds and Unconformities

The strata in the vicinity of Wales contain evidence of having been folded at least three times thru mesozoic and cenozoic time. The first of these orogenies was early Colorado and affected the Twist Gulch and Morrison formations. The evidence being that the Morrison-Indianola contact is an angular unconformity. Also the conglomerates of the Indianola formation suggest that there was a new positive source for these clastic sediments to the west. The next orogenic movement having occured after the deposition of the Indianola formation and affecting both the Jurassic and Indianola sediments is evidenced by the angular unconformity between the Price River and Indianola formations. Again the coarse conglomerate of the Price River formation suggest the development of a positive area to the near west. The third orogeny, involving the Price River, North Horn, Flagstaff, and Colton formations, folded the Gunnison Plateau into an asymmetrical syncline with the eastern limb sharply overturned.

The Geologic structure of the Wales Canyon area may be summarized briefly. In the southwest corner of the Wales area several hundred feet of the Colton formation are exposed. These tertiary rocks cap the Flagstaff formation and are the highest rocks in the area. Below and conformable to the Colton is the Flagstaff with a slight, but uniform dip to the west. The general strike of this formation and all the older formations is N 10° W. The lower 120 feet of the Flagstaff forms a prominent cliff that is easily traced along the Gunnison front. Below and conformable to the Flagstaff is the North Horn formation, a thick unit, measuring approximately 2500 feet in thickness. The dips increase going down through the section. At the base of the North Horn the dip increases rapidly from about 20° W to vertical. The contact between the North Horn and Price River formations is conformable and vertical or close to vertical. The thin unit of Price River conglomerate becomes slightly overturned at its base. It is this unit of quartzite conglomerate that makes up the prominent reef, through which Wales Canyon Creek has cut to form Wales Gap. In angular discordance to the base of the Price River formation is the Indianola conglomerate with an average overturned dip of 53° to the east. This discordance is visible at the base of the east slope of the reef in both Wales Gap and Deer Canyon water gap. Stratigraphically below the Indianola and at an angular discordance with it is the overturned Morrison sandstone and conglomerate unit. The next older unit also overturned and dipping about

53° E is the Twist Gulch formation, Jurassic in age. This formation extends east to the Sanpete Valley where it becomes covered by alluvium.

Faults

In the Wales Canyon area faults do not exist in the Tertiary rocks. The faults are in the Cretaceous and Jurassic rocks along the Gunnison front. There are two groups of faults present. One group striking about N 30° - 35° W, present in the Price River and Indianola conglomerates; and a second group striking further west, about N 70° - 60° W, which is present in the older Jurassic rocks. This general trend is true with the exception of one large E-W fault about 1.5 miles North of Wales Gap. This fault cuts the Twist Gulch, Morrison, Indianola and Price River formations. It is a normal fault upthrown on the south side and believed to be responsible for thickening the Indianola exposure here. These faults are normal faults. Displacement was not measurable on these faults because the bedding in the conglomerates and sandstones is not distinct. The two groups of faults may suggest that there were two periods in the geologic history of the area when the rocks were subject to tectonic forces from different directions.

Besides the normal faults there exists a long obligue thrust fault along the Gunnison front roughly trending N-S. This thrust fault cuts through both the Twist Gulch formation and the Morrison formation. North of Deer Canyon it thrusts the Twist Gulch sediments west over the Morrison sediments thus thinning the Morrison exposure in many places. At Deer Canyon, however, the fault thrusts the Morrison sediments west over the Indianola conglomerate. Along the Gunnison front at the edge of the Sanpete Valley there is another fault. This is a long normal fault, downthrown on the east and trending N-S. It is fairly recent because it has cut the pediment along the plateau front, leaving a 5 to 6 feet scarp along the unconsolidated deposits.

GEOMORPHOLOGY

On top of the plateau and in the amphitheater where the beds dip gently the drainage pattern is dendritic.

Near the base of the plateau where the resistant North Horn hogbacks and the vertical Price River cocks comb are present the streams develop a trellis type of drainage pattern. Here, the streams flow parallel to the resistant N-S trending rocks until they come to a water gap such as Wales Gap or Deer Canyon Gap and then they turn sharply east flowing towards Sanpete Valley where many of the streams die out on alluvial fans.

Where the streams cut through the bedrock they form V-shaped valleys. However, where they cut through alluvial deposits they form U-shaped trenches with high vertical sides. The Wales Canyon Creek is located in one of these U-shaped trenches at Wales Gap. These trenches are very difficult to cross.

The presence of the North Horn hogbacks and the Price River cocks comb can be attributed to the fact that the former is capped by limestone and quartzitic sandstone and the later consists of quartzitic conglomerate. Thus, both the hogback and the cocks comb exist because the errosional forces have not been able to disect the resistant rocks as readily as they have the nonresistant shale that is found stratigraphically above and below these features.

The semiarid climate plays an important role in the type of weathering. Because water is scarce, chemical weathering plays a minor role. Instead, mechanical weathering is dominent. Lack of chemical weathering is evident by the protective capping of shales by limestone. Frost wedging and heaving is evidenced by talus along the base of cliffs.

Because the hillsides are poorly covered by vegetation mass movements such as mud and debris slides do occur when sudden thunderstorms develop during the summer months or when the snow is slowly melting in the spring. A debris slide of cretaceous sediment is present about a half mile north of Wales Canyon road along the front of the cocks comb.

ECONOMIC GEOLOGY

Fuel

As mentioned earlier in the report, the North Horn formation contains several coal beds. Evidence of coal mining at the turn of the century on the Gunnison Plateau is provided by a number of abandoned coal shafts in Wales, Peach, and Coal Canyons. Some of the coal was used locally as fuel and a good deal was reduced to coke and sent by rail to Salt Lake City. The coal is bituminous and not of an exceptional quality. There is no active coal mining today.

Metallic Deposits

There is no evidence of mining of ores in the Wales Canyon area. However, several small lead and zinc mines exist on the Gunnison Plateau. The minerals are mined from sediments along mineralized faults. However, since mineralization of faults has been minor, no great zinc or lead mining industry exists.

Nonmetallic Deposits

Gravel

Gravel is quarried extensively throughout the area from quaternary terraces. These terraces generally exist at two levels along the plateau front. A lower level just slightly above the present alluvial valley, and a higher level exposed on divides between canyons. Near Wales the gravels consist mainly of coarse limestone and sandstone fragments probably derived from the North Horn and Flagstaff formations. A gravel pit exists on the north side of Wales Canyon road about 1,500 feet east of Wales Gap.

Limestone

Limestone is not quarried on the Gunnison Plateau. However, the regularly bedded limestone in the Green River formation is quarried at Temple Hill in Manti for building stone. This limestone was used for the construction of Manti Temple. The Flagstaff limestone also seems to be suited for use as a building material.

Salt and Gypsum

The Twist Gulch formation contains small amounts of salt and gypsum. The salt can be seen as a white crust on the dark red sediments. It is brought to the surface by evaporating water. The gypsum occures as small crystals of selenite. No economic concentration of these minerals exists along the Gunnison Plateau. Further to the south at Redmond Hills the undifferentiated Arapien and Twist Gulch formations are mined by open pit methods for salt.

GEOLOGIC HISTORY

General Statement

The geologically recorded history of the Wales Canyon area spans the time period from the Jurassic to the present. Varying depositional environments from marine to fluvial are recorded by the sediments during this period of time. Also there is evidence for at least three oragenic uplifts having taken place; two in the mesozoic era and one in the cenozoic era.

Mesozoic Era

Jurassic Period

During Jurassic time a calm, shallow sea occupied the Wales Canyon area. Into this sea were deposited the Arapien and Twist Gulch sediments. It is likely that there periodically existed closed basins during this time in which salt and gypsum were accumulating. The presence of salt and gypsum in these sediments indicates that the climate was probably warm. Next the Morrison sandstone and conglomerates were deposited. The deposition of the conglomerates probably took place while the sea began to retreat. The retreating sea was likely brought about by the same orogenic forces that provided a source for the conglomerates. Since the sediments became coarser to the west it is assumed that their source was from that direction. Near the close of Jurassic time there occured a period of quiescence during which time deposition ceased and perhaps the sediments became exposed to some errosion.

Cretaceous Period

During lower Cretaceous time the conditions which existed at the close of the Jurassic continued. Early in Upper Cretaceous time an orogenic movement took place to the west of the present Wales Canyon area. This orogeny provided a new source for sediments. Judging from the Indianola conglomerates that were deposited at this time, the orogeny was not far to the west. Thus, it may also have caused folding of the Jurassic sediments. The Indianola conglomerate was probably laid down as alluvial fans extending from the newly produced mountains and as channel fillings. After the deposition of the Indianola sediments they became subject to erosion. Towards the end of Upper Cretaceous time, the Laramide orogeny folded and uplifted the Indianola sediments which were eroded further. Upon this erosion surface of the Indianola was deposited the Price River conglomerate. These sediments were derived from the newly formed Wasatch Mountains. Sometimes towards later Cretaceous and Tertiary time deposition of the Price River gave way to deposition of the finer North Horn sediments during a period of alternating fluvial and lacustrian conditions.

Cenozoic Era

Tertiary Period

Paleocene Epoch. Deposition of the North Horn sediments continued into Paleocene time. The presence of coal between limestone in the North Horn sediments indicates that the climate was warm and that the depositional environment fluctuated between freshwater lakes and swamps. Sometime during Paleocene time geographical changes were effected by subsidence so that a large freshwater lake was formed into which were deposited the Flagstaff locustrian sediments.

Eocene Epoch. By Eocene time the large amounts of sediments deposited in the Flagstaff lake had caused it to become shallower and smaller. As the water was displaced from the Flagstaff lake a large and irregular flood plain resulted. On this floodplain Colton sandstones and shales were deposited in an intertongueing relationship with the Flagstaff formation. During middle Eocene time downwarping of the Uinta Basin produced the Green River Lake into which were deposited the lacustrian Green River sediments. Deposition continued until Miocene time when the lake had been displaced by sediments as the Flagstaff lake had been.

Miocene to Recent Time. Past Eocene history in the Wales Canyon area consists of periods of folding, faulting, and erosion to produce the present topography. After the deposition of the Green River formation the Wales Canyon area was subject to east west compressional forces which overturned the entire stratigraphic sequence forming a tightly overturned syncline. Continued stress caused an oblique thrust to develop in the Morrison and Twist Gulch formations, moving Morrison and Twist Gulch sediments west over other Morrison, Twist Gulch, and Indianola beds. Release of the compressional forces which folded the sediments into the overturned anticline possibly caused the extensive normal fault to develop along the base of the Gunnison Plateau, dropping the east side thousands of feet. Later faulting in the Price River and Indianola conglomerates produced large slide blocks and rubble along the front. The present appearance of the Wales Canyon area is the result of more recent erosion, alluvial deposition and debris slides.

Plate 4

Geologic History of the Wales Canyon Area

A-A' During Jurassic time the Arapien, Twist Gulch and Morrison sediments were deposited conformable with one another under marine conditions.

B-B' East ,west compressional forces resulted in uplifting an folding of the Jurassic sediments into a series of anticlines and synclines.*

Subsequent erosion of the folds followed.

C-C' During Cretaceous time deposition of Indianola strata as alluvial fans extending from the Wasatch Mountains.

Beginning of early Laramide folding, uplifting the Indianola sediments, and tightening of Jurassic strata into isoclinal folds by east west compressional forces.

Erosion of the uplifted surface.

Deposition during the Cretaceous period of Price River sediments onto the Indianola erosion surface.

Plate 4

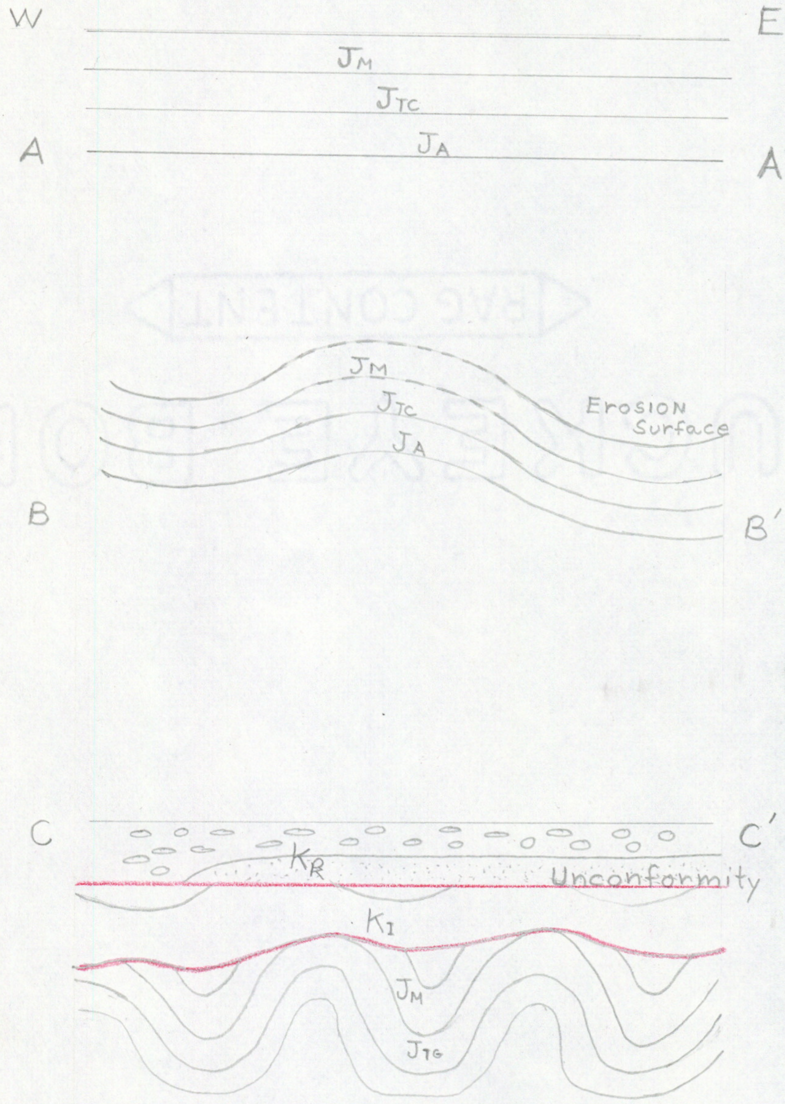


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Plate 5

Geologic History of the Wales Canyon Area

D-D' Continued deposition during later Cretaceous and Tertiary time of North Horn flood plain deposits and of Flagstaff, Colton, and Green River lacustrine and fluviatile beds.

Compressional forces from the eas folding the entire sequence up to the west.

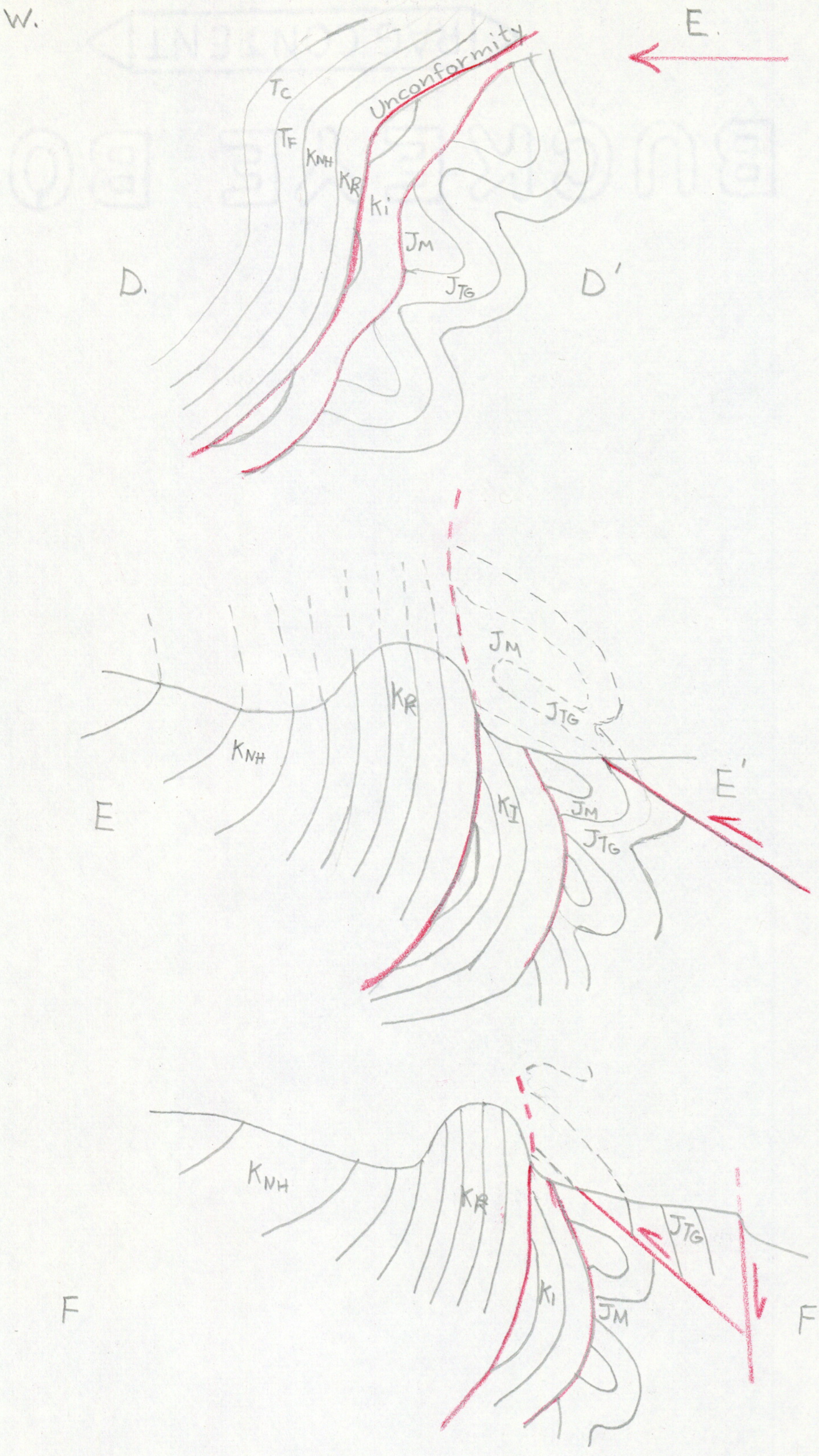
E-E' Continued Laramide orogenic activity with Compressional forces from the east overturning strata through North Horn with a shallow syncline developing in the younger sediments.*

Continued stress causing thrusts oblique to the trend of the beds to develop between the Morrison and Twist Gulch formations, moving Morrison, and Twist Gulch west over other Morrison, Twist Gulch, and Indianola beds.

F-F' Release of the compressional forces, in combination with the extreme overturning of the east flank of the Price River, ect. Anticline, causing an extensive normal fault to develop along the base of the Gunnison Plateau, dropping the east side thousands of feet. Movement possibly continuing.

Associated faulting in which blocks of Price River were faulted to horizontal and underlying Indianola to vertical, producing later slide blocks and rubble in adjacent areas.

Plate 5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Erosion, canyon formation, and alluvial deposition.

Debris slides or flows and erosion to present topography.

Alternative #1*

Normal deposition through Indianola. Folding the entire section into simple anticlines and synclines. Compressional forces producing overturning and isoclinal drag folds in the Morrison and Twist Gulch formations in which areas of weakness there later developed thrusts.

Alternative #2*

History as presented until approximately Lance time during which the Price River and Noth Horn basal conglomerate were folded and asymmetrically overturned. Followed by normal deposition of the remainder of the North Horn and of the Flagstaff and Colton and Green River. After which, compressional forces formed a shallow syncline in Tertiary sediments tightening the previously formed, deeper, asymmetrical, over-turned syncline.

Alternative #3

A combination of the history as presented and a substituting of both alternatives #1 and 2.

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